2007

Physical Therapy Diabetic Protocol

Jered Field
University of North Dakota

Jason Hahn
University of North Dakota

Corey Samuelson
University of North Dakota

PHYSICAL THERAPY DIABETIC PROTOCOL

by

Jered Field
Bachelor of Science
Southwest Minnesota State University, 2004
Jason Hahn
Bachelor of Science in Physical Therapy
University of North Dakota, 2005
Corey Samuelson
Bachelor of Science
North Dakota State University, 2004

A Scholarly Project

Submitted to the Graduate Faculty

of the

University of North Dakota

in partial fulfillment of the requirements

for the degree of

Doctor of Physical Therapy

Grand Forks, North Dakota
May
2007

This scholarly project, submitted by Jered Field, Jason Hahn, and Corey Samuelson in partial fulfillment of the requirements for the Degree of Doctor of Physical Therapy from the University of North Dakota, has been read by the Faculty Advisor under whom the work has been done and is hereby approved.

Cindy Flom-Meland
Graduate Advisor

Thomas Mon
Chairperson

PERMISSION

Title Physical Therapy Diabetic Protocol

Department Physical Therapy

Degree Doctor of Physical Therapy

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Date 12/14/06

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ACKNOWLEDGMENTS

We would like to thank our faculty advisor, Cindy Flom-Meland, PT, PhD, for all her time, patience, and expertise which she shared with us throughout the completion of this project.

Our thanks to the rest of the faculty for all their time and knowledge which helped sculpt us into the physical therapists we will become in the future.

Finally, a special thanks to our families for all of your encouragement, love, and support given throughout school and life. We could not have done it without you.

ABSTRACT

As the number of individuals in the United States with Type II Diabetes continues to increase significantly, so too does the incidence of lower extremity secondary complications. Ulcer care and possible lower extremity amputation are very expensive to patients and the healthcare system and can be extremely debilitating. Preventative measures have been implemented; however, a greater focus in this area may provide significantly greater results. Previous research states that preventative programs for lower extremity complications are cost effective if they can provide a 25% decrease in these conditions. In this project, a comprehensive prevention program has been designed to increase physical therapy involvement in this process. Included in this program is a diabetes diagnosis foot screening and an individualized treatment plan which utilizes patient education, footwear, orthotics, and exercise components.

CHAPTER I

INTRODUCTION

The rate of Americans with type II diabetes continues to rise throughout the United States.[1] In 2002, diabetes mellitus was the sixth leading cause of death in the country.[2] A wide variety of debilitating conditions arise secondary to this disease, including ulcer development and subsequent lower extremity amputations. Changes that can lead to diabetic complications of the lower extremities include neuropathy development and vascular restriction.

The cost of ulcer and/or amputation treatments is extremely expensive and poses many problems for the patient and health care provider. Ulcer care can be a very lengthy process, may cause a loss of independence to individuals who develop them, and often result in ulcer recurrence. Lower extremity amputation results in a much greater loss of independence and often leads to a greatly decreased lifespan.[3] Prevention of these conditions is a key aspect of diabetic care which centers directly on blood sugar control with a proper diet and exercise. A proper diet will help maintain proper blood glucose levels. Exercise has many health benefits for patients with diabetes including increasing sensitivity of insulin. Other preventative measures include maintenance of proper foot structure, range of motion, strength, and utilization of proper footwear.

One of the most common problems that occurs secondary to aging and with the progression of diabetes is the loss of ankle dorsiflexion motion. The loss of dorsiflexion motion is especially problematic as it leads to increased pressure on the plantar surface of the foot during gait.[4] Strength loss in the foot/ankle, which may or may not be related to neuropathy development, often causes changes in the normal foot structure. Improper footwear can lead to a variety of problems in the foot including rubbing, vascular restriction, foot structure changes, and a general inability of the foot to function correctly. All of these conditions may trigger the process of callus and eventual ulcer formation.

In this study, we are developing a physical therapy screening and intervention program to help decrease incidence rates of these current medical problems. The screening program includes a thorough examination of foot structure, foot/ankle ROM, and current footwear. Intervention from this screening may include recommendation for foot orthotics, education on proper shoe wear, and assignment of an ankle stretching program. Further intervention would include education and development of a personalized exercise program. Current diabetic programs for newly diagnosed patients focus mainly on patient education about the disease. These programs are limited in direct preventative measures. We believe instituting a greater prevention program will help decrease the formation of neuropathies and further foot problems.

CHAPTER II

LITERATURE REVIEW

The incidence of diabetes continues to rise to epidemic levels today; the direct and secondary complications of the disease present a wide variety of complications to its patients and the healthcare system. The Center for Disease Control reported that from 1980 to 2004 the number of people with diabetes in the United States more than doubled.[5] One and a half million new cases of diabetes were diagnosed in people aged 20 years or older in 2005 alone.[6] These numbers continue to rise today and project to frightening levels in future years.

As the number of people with diabetes in the United States continues to grow, so does the number of people who develop secondary complications including neuropathy, ulcer formation, and lower extremity amputation. These conditions of the lower extremities pose a wide variety of problems to the healthcare system. Ulcer care is extremely time-consuming and expensive both for those who develop them as well as the healthcare providers involved in their treatment. In a study conducted by the American Diabetes Association, Stockl and colleague[3] examined the healthcare costs associated with diabetic lower extremity ulcers. In this study, the claims data for over 2,200 patients with diabetes who received ulcer care were assessed to compute an estimate of total

ulcer care costs. They reported the average cost of one episode of ulcer care was found to be $13,179 and lasted approximately 87 days. Stockl et al[3] found that inpatient hospital costs accounted for approximately 77% of total ulcer care cost, signifying it as the major cost driver.

An earlier study by Ramsey et al[7] conducted in 1998 examined the total healthcare costs of individuals with diabetes who developed a lower extremity ulcer and compared the costs with a control group who had no ulcer formation or history. In this study at the University of Washington, the researchers reported the average cost of ulcer care for a 40- to 65-year-old individual with diabetes was $27,987 for total care two years post ulcer diagnosis.

Unlike the Stockl and colleagues[3] study, the research conducted by Ramsey et al[7] included costs of subsequent ulcer formation and further complications that may have developed, such as lower extremity amputations within a two-year period post diagnosis. When comparing the costs of the individuals with ulcers to the control group, the authors found that the costs for the experimental group was 1.5 to 2.8 times greater than the control for the first year after diagnosis. Examination of the costs for the second year post diagnosis displayed a relative cost of care up to 5.4 times higher in the experimental group.

Despite an increase in diabetes education and awareness along with greater examination by healthcare providers, ulcer development continues to be relatively common. In the same study by Stockl et al[3], it is reported that approximately 2-3%of individuals with diabetes develop a foot ulcer annually,

with 15% developing one sometime in their lives. In a literature review conducted by Boulton et al[8], the authors state the lifetime risk of ulcer formation may be as high as 25%. In this report, both the incidence and costs of care are examined for various regions of the world. Among the concepts discussed in this report is the recurrence of ulcers in patient with diabetes. Boulton et al[8] reported that the rate of recurrent foot ulcers is greater than 50% after three years.

Ulcer formation is only the beginning of the problem, however, as progression to infection, osteomyelitis, or even lower extremity amputation often occur. Ramsey et al[7] observed individuals with diabetes over a three-year period and reported that 11.2% of those patients who developed an ulcer had a subsequent lower extremity amputation. Boulton et al[8] stated that in 1997 nearly 70% of all amputations in North America resulted from patients with diabetes. In addition, Stockl et al[3] reported that diabetic lower extremity ulcers are responsible for 92,000 amputations annually.

Lower extremity amputation leads to a significantly greater level of complication and cost to the patient and healthcare system. Ulcers resulting in lower extremity amputation result in hospital costs three to five times that of average ulcer care costs. In the global study by Boulton et al[8], minor lower extremity amputation (foot level) resulted in average costs of $43,800 and escalated to $66,215 for major lower extremity amputations (above ankle).

Of exceeding importance to that of the large costs is the considerable decrease in quality of life and life expectancy for those who undergo a lower extremity amputation. In the study conducted by Stockl et al[3], it was found that

within five years of the first amputation, 28-51% of patients with diabetes require a second amputation. The authors also report that survival is bleak, as only 27% of individuals with diabetes who experience an amputation survive five years post operation.

In order to reduce these debilitating conditions, a focus on greater patient education and preventative measures has been initiated. Broad improvements continue to be needed in this area. A wide-scale approach encompassing diabetic education, foot care, and proper footwear is needed in greater outcomes. Boulton et al[8] reported that a prevention program following this approach could be cost effective if it can result in a 25% decrease in diabetes-related lower extremity amputations.

Orthotics

Foot complications are a significant cause of morbidity in patients with diabetes and may cause long episodes of hospitalization and amputation.[9] These complications may develop because of sensory, motor, nerve, vascular, and/or biomechanical dysfunctions.

Skin breakdown, such as plantar callus, is commonly seen in people with diabetes which may lead to severe complications if left untreated. Calluses are a result of hypertrophy of the stratum corneum with excess keratinisation and it indicates abnormal foot pressures.[9] These abnormal foot pressures are many times the result of biomechanical dysfunctions of the foot. Orthotics are used to place the foot in its most biomechanical stable and efficient position to prevent abnormal pressures. Therapeutic footwear and orthotic devices are the primary

means of protecting the foot from excessive plantar pressures during walking. Some research indicates that therapeutic footwear can reduce the incidence of ulceration in people with diabetes.[9-12]

Colagiuri et al[9] involved patients with diabetes and separated them into two different treatment groups which involved a conventional treatment and orthotic device treatment. Each subject was assessed by a podiatrist and 12 months later reassessed. They found the orthotic group demonstrated a significant reduction in callus grades with no adverse effects while the conventional treatment group demonstrated no significant changes.

A major area of concern for patients with diabetes is excessive plantar stresses and contact time at the metatarsal heads.[13] If this goes untreated, it may lead to skin breakdown, peripheral neuropathy, and possible amputation. According to Mueller et al,[10] the use of specialized footwear, such as orthotic inserts in combination with metatarsal pads, significantly reduces excessive pressure under the metatarsal heads by increasing the foot's contact area. Mueller[10] studied 20 subjects with diabetes, peripheral neuropathy, and/or history of foot ulcers. The research was done to assess the outcomes of three different footwear designs, such as a shoe, a shoe with total-contact inserts, and a shoe with total-contact inserts and metatarsal pads. Mueller et al[10] found the combination of total-contact inserts and metatarsal pads were the most beneficial and that peak plantar pressure decreased 14-24% at the metatarsal heads.

A study by Viswanathan[12] examined different types of footwear insoles for patients who have a diabetic neuropathic foot. The patients who used therapeutic footwear showed lower foot pressure while those patients who used non-therapeutic footwear an increase in foot pressure. This research study also showed a 33% increase in new lesions for the patients who used their own footwear of choice compared to 4% of all other groups.[12] Therapeutic footwear in general decreased the occurrence of new ulcers and may also decrease the rising amputation rate as a result of diabetes.

Pinzur et al[14] compiled a one-page written survey to be filled out by 02 randomly selected patients with diabetes during their physicians visits. The patients in this study averaged 61.5 years of age and had a length of diagnosis of 27.3 years. This study shows that one-fourth of patients with diabetes are at risk of developing complications due to this disease. This study was done to obtain information from the diabetic population on the level of knowledge of diabetes and what if any prophylactic foot care is provided to these patients. The results of this study suggest that many of the patients and physicians are aware of he problems associated with diabetes, yet the majority do not take advantage of the prophylactic footwear. Very few patient are taking advantage or even know about the Medicare Foot Bill which gives the patient an opportunity for preventative care long-term.

Medicare Shoe Bill

The Medicare Shoe Bill provides coverage for therapeutic shoes, inserts, and shoe modifications for qualifying patients with diabetes. Medicare will pay

80% of these items.[15] Each individual is limited to one of the following for one calendar year: one pair of custom-molded shoes with three pairs of removable inserts or one pair of depth shoes. Depth shoes have a full-length removable insole that, when removed, provides additional depth throughout the shoe. Modifications of custom-molded shoes or depth shoes may be substituted for a pair of inserts.[15,16]

The patient must fulfill all the following requirements: has diabetes, is being treated under a comprehensive plan of care, and has one or more of the following conditions–peripheral neuropathy with evidence of callus formation, history of ulcers, history of preulcerative calluses, foot deformity, previous amputation of the foot or part of the foot, and/or poor circulation.[15,16]

To obtain coverage, a "Statement of Certifying Physician for Therapeutic Shoes" must be completed by the treating physician indicating therapeutic shoes are necessary. One must also have a prescription from one of the following: podiatrist, pedorthotist, orthotist, or prosthetist.[15,16] The prescription is then relayed to a qualified footwear provider for furnishing the shoes, inserts, and modifications. The prescribing physician may be the supplier. The certifying physician may only be the supplier if the patient is residing in a defined rural area or a defined health professional shortage area.

Proper Shoe Wear

Mousley[17] stated that patients with diabetes and associated foot neuropathy are susceptible to injury caused by their footwear. Many different

complications can be caused by improper footwear, including ulcer formation, callus formation, toe deformities, and muscle imbalance.

According to Mousley,[17] there are many different areas that need to be examined with each purchase of shoes, such as the size, width, material, toe area, cushioning, shock absorption, heel height, and style of tightening. Due to the fact that foot size and shape change because of forces throughout the day, shoes should be purchased at the end of the day. Measurements of the feet should be taken by a trained staff member while standing and shoe should be tested before purchase. This includes trying on the shoe to make sure that it is comfortable during activities in which the purchaser will be taking part.

Mousley[17] states that for proper fitting there should be 1 centimeter between the end of toes and the end of the shoe in weight-bearing. Shoes that are broad fitting and rounded in the toe area result in decreased pressure and increased comfort. Soft leather uppers allow the best ventilation. Shoes should not allow for the foot to slide around while ambulating and heel height should never be above 2.5 cm or around 1 inch in height.

Benefits of Exercise

Exercise is an important component of health for patients with diabetes. There are many different factors that need to be evaluated to get the correct exercise program for each patient. Other areas that can be individualized are frequency, intensity, type, and duration of exercise. The major components of an effective exercise program include aerobic exercise, strength training, and flexibility.

Patients' compliance with their exercise program is also a major component of a successful exercise program. Koenigsberg et al[18] stated that 20 to 50% of all patients with diabetes can treat their disease with modification of their diet and an exercise program of at least 150 minutes of exercise per week. Exercise has been proven to help in many different areas of health for patients with diabetes. Not only doe sit help decrease many health risk factors, exercise can also decrease stress and increase an individual's confidence.

The main area for which a proper exercise program provides the largest improvements is the cardiopulmonary system. Bjorgaas et al[19] found that exercise has been shown to increase VO_2 max in patients with diabetes that increase their aerobic activity.

In a study by Loretta et al,[20] six different exercise groups were set up to measure which group gained the most health benefits after exercise. The groups were split from 0 METS per hour per week (METS-h-1-week-1) to greater than 40 METS-h-1-week-1 by increments of 10 METS-h-1-week-1. After two years, the groups that performed 0 to 10 METS-h-1-week-1 showed no improvements in health status. In the groups that performed 11 to greater than 40 METS-h-1-week-1 improvements were seen in hemoglobin type A (HbAlc) (a major predictor for diabetic complications), blood pressure, total serum cholesterol, triglycerides, and decrease estimated percent of 10-year coronary heart disease risk. In the groups that performed 21 to greater than 40 METS-h-1-week-1 improvements were seen in body weight, waist circumference, heart rate, fasting plasma glucose, serum low density lipoprotein (LDL) and high

density lipoprotein (HDL). When evaluating the cost of medications per year, the group that performed no exercises saw an increase in medications on average of $393 and in the group that performed 31-40 MET-h-1-week-1 decreased their medication cost by an average of $660. By performing greater than 10 METS-h-1-week-1 through aerobic physical activity, participants received some health and financial advantages, but full benefits were achieved when energy expenditure was greater than 20 METS-h-1-week-1.

Flexibility is also a key aspect to an effective exercise program. Increased peak plantar pressure, due to a variety of changes in foot structure or range of motion (ROM), is a major cause of diabetic foot ulceration. Goldsmith et al[4] found that completion of a home stretching program to increase ROM in the ankle (primarily dorsiflexion) results in a decrease in peak plantar pressure an average of 4.2% of each period of gait cycle. The home stretching program consisted of a warm-up, followed by five sets of multiple passive and active stretching exercises. These stretches work on many different motions of the foot and ankle including dorsiflexion, plantarflexion, supination, and pronation. Following all stretching exercises, the participant would perform a cool-down and soft tissue mobilizations to the foot, ankle, and lower leg.

As stated above, all aspects of exercise (aerobic, strength, flexibility) is needed for patients to reach their optimal potential for diabetic therapy. Strength training has also been shown to help improve risk factors for patients with diabetes. Cauza et al[21] reported that strength training has been shown to decrease fasting glucose levels, diabolic blood pressure, cholesterol, and HbAlc

levels. The strength training program was performed for four months exercising on three non-consecutive days. The beginning of the program was based off minimal level strength training. By the third week, exercises were aimed at hypertrophy. Areas of the body that were worked on included the pectoralis, trapezius, latissimus dorsi, back muscles, biceps, triceps, abdominals, quadriceps, calf muscles, and hamstrings.

The cost of treatment for patients with diabetes including medications, ulcer therapy, amputations, vision, and any other complications is extremely expensive. Loretta et al[20] reported that compliance in an exercise program can result in a decrease in medical prescription costs, other medical costs, and indirect social costs up to $2,000 in two years. Overall, exercise can improve the patients with diabetes quality of life by decreasing the incidence of major risk factors and diabetic complications, as well as decreasing the cost of diabetic treatment.

Currently, physical therapists are mainly involved in the treatment of diabetes after complications arise. Physical therapists can play a major role in the preventative care of this disease. With the inclusion of a diabetic questionnaire, foot screening, and development of an exercise program, physical therapists can help patients with diabetes prevent secondary complications.

CHAPTER III

QUESTIONNAIRE, EVALUATION, DECISION-MAKING TREE

The authors developed a diabetic history questionnaire, physical therapy examination form, and a clinical decision-making tree. These tools allow a physical therapist to evaluate the patient's condition and assist in the appropriate decision-making process to provide proper intervention. The diabetic history questionnaire was designed to receive an understanding of the individual's type of diabetes and complications that may arise. It may give the therapist insight on compliance issues in their management, as well as a systems review for proper referral if necessary (see Appendix A).

The examination form (Appendix B) was designed to test for deficiencies common to patients with diabetes, such as abnormal range of motion/strength which can result in increase pressures/stresses on the foot/ankle. It also includes an assessment of a patient's vascular supply for decrease blood flow in the lower extremities as well as sensation, skin conditions, and foot structures. Abnormalities found in any of the categories within the examination can lead to secondary complications. The examination was standardized and a detailed description of each section has been included (see Appendix B). The clinical decision-making tree was designed to help the physical therapist make proper decisions on abnormalities found within the examination. It also allows the

therapist to choose the appropriate intervention for each individual's condition (see Appendix C).

CHAPTER IV

PAR-Q, EXERCISE PROGRAM

The PAR-Q evaluation and guidelines were included for starting an exercise program. Incorporated in the exercise guidelines are contraindications and special considerations for individuals with diabetes. Use of this information should provide the ability to develop a comprehensive and individualized exercise program (see Appendix D).

The PAR-Q was designed to identify any person for whom physical activity would be contraindicated or those who should have medical advice on activities that are safe for their specific conditions. The exercise guidelines contain variables that enable the physical therapist to individualize an exercise program for a patient with diabetes. It encompasses items to consider before, during, and after exercising. The program includes all the components of exercise, such as aerobic, strength training, and flexibility (see Appendix E).

CHAPTER V

CONCLUSION

Type II diabetes is rising to rates never seen before in the American population. Secondary complications associated with this disease can be very debilitating physically, emotionally, and economically. If preventative measures and treatments are not followed, diabetes complications can often lead to lower extremity ulcer formation or amputations.

The cost of ulcer and/or amputation treatments is extremely expensive and poses many problems for the patient and health care provider. Lower extremity amputation results in a much greater loss of independence and often leads to a greatly decreased lifespan. Prevention of these conditions is a key aspect of diabetic care which centers directly on blood sugar control with a proper diet and exercise. Exercise has many health benefits for patients with diabetes, including increasing sensitivity of insulin. Other important preventative measures include maintenance of proper foot structure, range of motion, strength, and utilization of proper footwear.

We developed a physical therapy examination procedure and intervention program to help decrease incidence rate of these current medical problems. The examination includes a thorough evaluation of foot structure, foot/ankle ROM, sensation, and current footwear. Intervention after this screening includes

education on proper shoe wear, recommendation for foot orthotics (if necessary), and assignment of an ankle stretching program. Further intervention will include education and development of a personalized exercise program. Current diabetic programs for newly diagnosed patients focus mainly on patient education about the disease. These programs are limited in direct preventative measures. We believe that the increased involvement of physical therapy through the implementation of this program will significantly decrease secondary lower extremity complications. People with type II diabetes have the potential to come away from this assessment without any complications. These patients will then have the proper education to self-monitor for any signs of complications. As a result, many individuals with diabetes should see a significantly decreased cost of healthcare and experience a much greater quality and length of life.

APPENDIX A

Diabetes Questionnaire

Please Print

Name:_____ Date of Birth:_____

1. What type of diabetes do you have?_____

2. When were you diagnosed with diabetes?_____

3. Who is your primary physician?_____

4. When was your last visit?_____

5. What was your last blood sugar measurement?_____

6. Please approximate your average blood sugar level._____

7. Are you currently on any medications, including insulin? If so what?_____
_____

8. Do you have any other medical conditions?_____
_____

9. Do you have any family history of diabetes?
   ☐ Yes ☐ No

10. Have you consulted with a dietician?
   ☐ Yes ☐ No

11. Have you experienced any unusual weight loss?
   ☐ Yes ☐ No

12. Do you smoke tobacco or drink alcohol?
   ☐ Yes ☐ No

   If so how much?_____
   _____

13. Have you had any of the following complications with diabetes? If so please check the boxes below.

- ◻ Heart conditions
- ◻ Stroke
- ◻ Eye conditions
- ◻ Neuropathy
- ◻ Other_____
- ◻ Foot complications: ulcers
- ◻ Skin conditions: Infections
- ◻ Nail conditions: Thick/Brittle
- ◻ Gastroparesis
- ◻ Depression

14. Have you had prior treatment for these complications, if so what?

◻ Yes ◻ No

_____

_____

15. Did the treatments help?

◻ Yes ◻ No

If so, how long did it take for them to help?_____

_____

_____

16. Do you exercise?

□ Yes □ No

If so what does your program consist of?_____

_____

How many days per week do you exercise?_____

17. Have you heard of the Therapeutic Shoe Bill?

◻ Yes ◻ No

If so are you currently utilizing this bill?

□ Yes □ No

If not, would you like some information?

□ Yes □ No

APPENDIX B

Diabetes Examination Form

Name:_____

Date:_____

Evaluator:_____

ROM/Strength

Right ROM	**Right MMT**		**Left ROM**	**Left MMT**
		Ankle Dorsiflexion		
		Ankle Plantarflexion		
		Ankle Inversion		
		Ankle Eversion		
		Great Toe Extension		
		Great Toe Flexion		
		Digits Extension		
		Digits Flexion		

Other comments:_____

_____

_____

Vascular

Grade pulse as normal, bounding, weak or absent

Right		**Left**
	Dorsal Pedal Pulse	
	Posterior Tibial Pulse	

Capillary Refill Time

Right		**Left**
	Capillary refill < 3 sec	

Other comments:(Please note any changes in skin. Ex: shiny, hairless, atrophic skin)_____

_____

_____

Diabetes Examination Form

Name:_____

Date:_____

Evaluator:_____

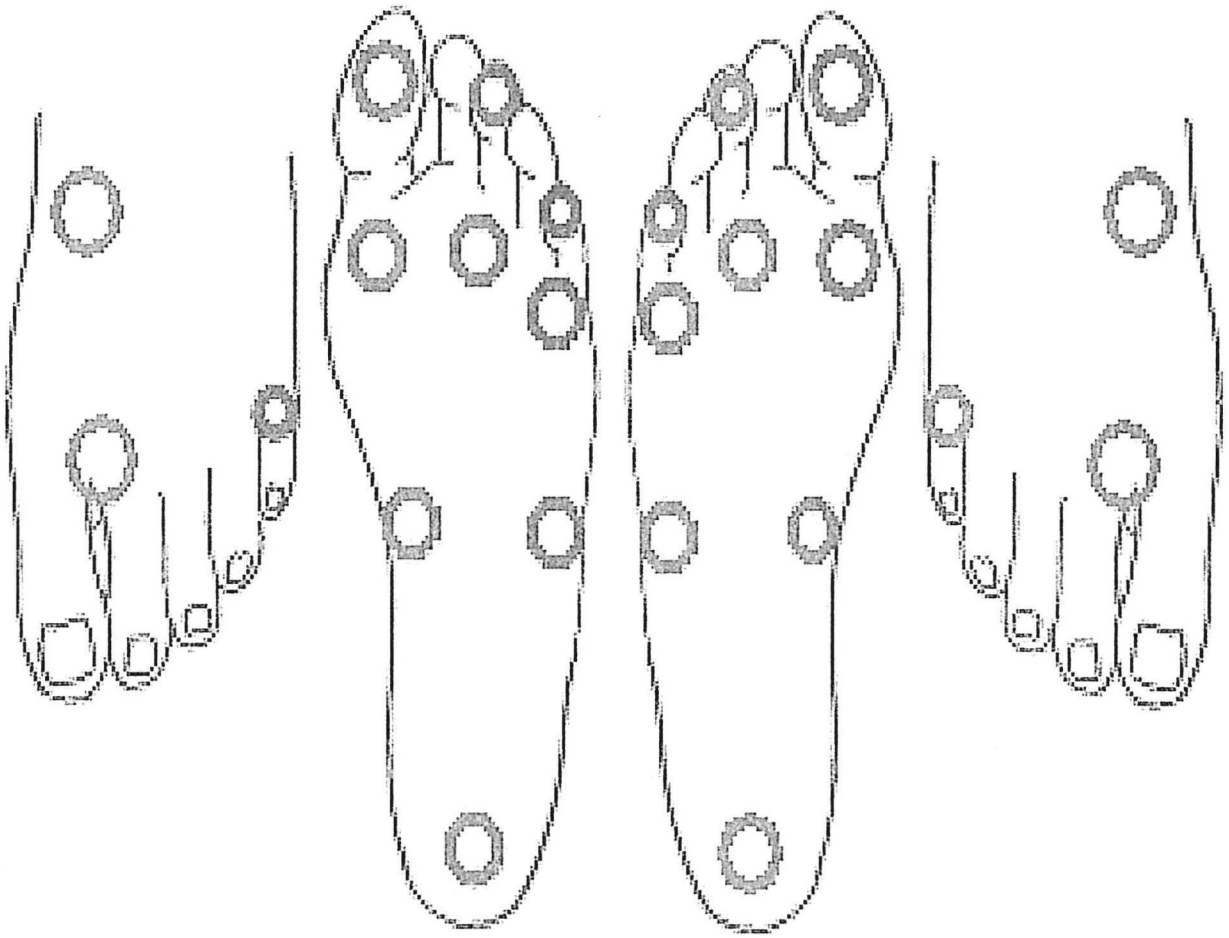
Sensation

Sensory Level: 1= 1gm, 2=10gm, 3= 75 gm, 4=>75gm

Skin evaluation: Label D= dryness, S= swelling, R= redness, T= temperature

M=maceration, C= callus, P= pre-ulcer, U= ulcer

Left **Right**



Other comments:_____

_____

_____

_____

_____

_____

_____

Diabetes Examination Form

Name:_____

Date:_____

Evaluator:_____

Deformities

Right		Left
	Hammer/Claw Toes	
	Bunion/Bony prominence	
	Pes Planus/Cavus	
	Rearfoot/Forefoot Varus	
	PF 1st Ray/Forefoot Valgus	
	Dorsiflexed First Ray	
	Equinus/Calcaneus	
	Drop Foot	
	Charcot Fracture	
	Hallux Limitus	
	Partial Foot Amputation	

Other comments:_____

_____

_____

Shoe Inspection

Standard shoe Y□ N□ Prescription Y□ N□

Yes		No
	1cm space at end of shoe	
	Wide Forefoot	
	Snug heal	
	Soft leather uppers	
	Heal height <2.5 cm or 1 inch	
	Padded topline	
	Cushioned sole, flexible at ball only	
	Types of Socks (list below)	

Other comments:_____

_____

_____

Signed:_____ **Date:**_____

Examination Instructions

Foot/Ankle ROM Assessment[22,23]

Passive ROM of the ankle is assessed using force generated by the assessor to move the ankle into the patient's end range of motion. Ankle dorsiflexion, plantar flexion, inversion, and eversion are tested in a short sitting position with the patient's feet elevated above the ground. A functional assessment of ankle dorsiflexion is also measured in a weight bearing position with the patient assuming a staggered position with his/her back knee straight and back heel flat on the ground. The force into dorsiflexion is produced by the patient shifting his/her weight forward to the end point where the heel must raise off the ground and/or the back knee must bend. Correct assessment requires the use of a goniometer and the assessor assuming an eye level position during measurement. Assessment of ROM for phalangeal segments requires the use of an appropriate size goniometer and stabilization of the proximal segment during measurement.

Dorsiflexion and Plantar Flexion in Short Sitting
Goniometer Placement

- The fulcrum of the goniometer is placed over the lateral aspect of the lateral malleolus.
- The proximal arm is positioned parallel to the shaft of the fibula.
- The distal arm is positioned parallel to the shaft of the 5th metatarsal.

Inversion and Eversion in Short Sitting
Goniometer Placement

- The fulcrum of the goniometer is placed lateral to the 5th metatarsal head when measuring inversion and medial to the 1st metatarsal head when measuring eversion.
- The proximal arm is aligned with the veretical plane.
- The distal arm is placed along the plantar surface of the metatarsal heads.

Functional Passive Dorsiflexion in Weight Bearing
Goniometer Placement

- The fulcrum of the goniometer is placed over hte lateral aspect of the lateral malleolus.
- The proximal arm is positioned parallel to the shaft of the fibula.
- The distal arm is positioned parallel to the shaft of the 5th metatarsal or the ground.

Flexion and Extension of Phalangeal Joints
Goniometer Placement

- Metatarsophalangeal Joint (MTP) - Goniometer placed in contact with dorsal surface (proximal arm over the metatarsal and the distal arm over the proximal phalanx) of the foot with the fulcrum at the MTP joint.
- Proximal Interphalangeal Joint (PIP) - Technique same as above with fulcrum on dorsal surface of PIP joint, proximal arm over proximal phalanx and metatarsal and distal arm over the middle or distal phalanx (great toe).
- Distal Interphalangeal Joint (DIP) - Technique same as above with fulcrum on dorsal surface of DIP joint, proximal arm over proximal and middle phalanges, and distal arm over distal phalanx.

Manual Muscle Testing[24]

Manual Muscle Testing will be conducted using a 0-5 scale. A score of 0 (ZERO) denotes no evidence of contraction. A slight contraction is scored as a 1 or TRACE grade. A score of 2 is POOR and signifies movement through partial range against gravity. A FAIR grade of 3 is given to movement through the complete range against gravity. A GOOD rating of 4 is given if the patient is able to complete full range of motion against gravity and give some resistance against an outside force. A score of 5 is considered NORMAL, and is given when the patient is able to hold a position against maximal resistance. Each movement will be demonstrated on the patient's foot/ankle prior to testing for his/her familiarity with the motion. Overpressure will be applied through external force from the physical therapist for all segments. Alternative quick tests may be completed for ankle plantar flexion and dorsiflexion by having the patient raise up on his/her toes and heels, respectively, in single leg stance. Normal strength grades will be given if the patient can complete 5-10 repetitions. Patients completing 1-4 repetitions will be given a grade of 4. Patients unable to complete the alternative test will complete the non-weight-bearing positions.

Ankle Plantar Flexion
- *Position* - Prone lying with foot and ankle off the table
- *Palpation* - Posterior aspect of the calf
- *Stabilization* - Anterior aspect of distal leg
- *Resistance* - Superoposterior aspectc of calcaneous with force into dorsiflexion

Alternative Position for Ankle in Weight Bearing
- *Position* - Single leg stance with full weight bearing and table at side used for balance
- Patient is instructed to rise up on his/her toes as many times as possible
- NORMAL (5) grade is given if the patient is able to complete at least 5 repetitions
- GOOD (4) grade is given if the patient is able to compelte 1-4 repetitions

Ankle Dorsiflexion
- *Position* - Supine position with foot and anke off the table
- *Palpation* - Anterior surface of ankle joint at level of malleoli
- *Stabilization* - Posterior aspect of distal leg
- *Resistance* - Dorsal surface of the foot at metatarsal region with force into plantar flexion

Alternative Position for Ankle Dorsiflexion in Weight Bearing
- *Position* - Single leg stance with full weight bearing and table at side used for balance
- Patient is instructed to rise up on his/her heels as many times as possible
- NORMAL (5) grade is given if the patient is able to complete at least 5 repetitions
- GOOD (4) grade is given if the patient is able to complete 1-4 repetitions

Substalar Inversion
- *Position* - Sidelying on side to be tested with the top knee bent and the bottom foot and ankle off the table
- *Palpation* - Posterior and distal to medial malleolus
- *Stabilization* - Anteromedial aspect of tibia
- *Resistance* - Medial aspect of foot with force into eversion

Subtalar Eversion
- *Position* - Sidelying with the side to be tested up, bottom knee bent, and top foot/ankle off the table
- *Palpation* - Posterior to the medial malleolus
- *Stabilization* - Medial aspect of the distal leg
- *Resistance* - Lateral border of the foot with force into inversion

Metatarsophalangeal Joint (MTP) Flexion
- *Position* - Short sitting off table
- *Palpation* - Muscles are too deep for palpation
- *Stabilization* - Plantar and dorsal surfaces of metatarsals
- *Resistance* - Plantar surface of proximal phalanges with force into extension
- Flexion of the great toe is conducted separately, with digits 2-4 completed together

Metatarsophalangeal Joint (MTP) Extension
- *Position* - Short sitting off table
- *Palpation* - Dorsal surface of the foot proximal to the MTP joint of the digit tested
- *Stabilization* - Plantar and dorsal surfaces of metatarsals
- *Resistance* - Dorsal surface of proximal phalanges with force into flexion

- Extension of the great toe is conducted separately, with digits 2-4 completed together

Vascular Testing

Vascular insufficiencies are also major problems with diabetic patients. With vascular insufficiencies, patients will have decreased healing potential and may also cause tropic changes which can cause the skin to be at a higher risk for wound formation. The two main pulses to take in the lower extremity are the dorsalis pedis and the posterior tibialis.

Monitoring Pulse[25]
Select the pulse point to be monitored. Count pulse for 30 seconds and multiply times two. Note rhythm, volume, and quality or feel of the vessel. The rate should range from 60 to 90 beats per minute. The rhythm is regular and time intervals should be constant. The volume or force should be equal with each beat/. The pulse should be graded as bounding, normal, weak, or absent.

Dorsalis pedis pulse[26]-Dorsalis pedis pulse varies from patient to patient and some pulses will be stronger than others. The pulse is generally found running between the first and second metatarsals.

Figure 1. Dorsalis pedis pulse.

Posterior tibialis pulse[26]-The posterior tibial artery can be palpated posterior and inferior to the medial malleolus.

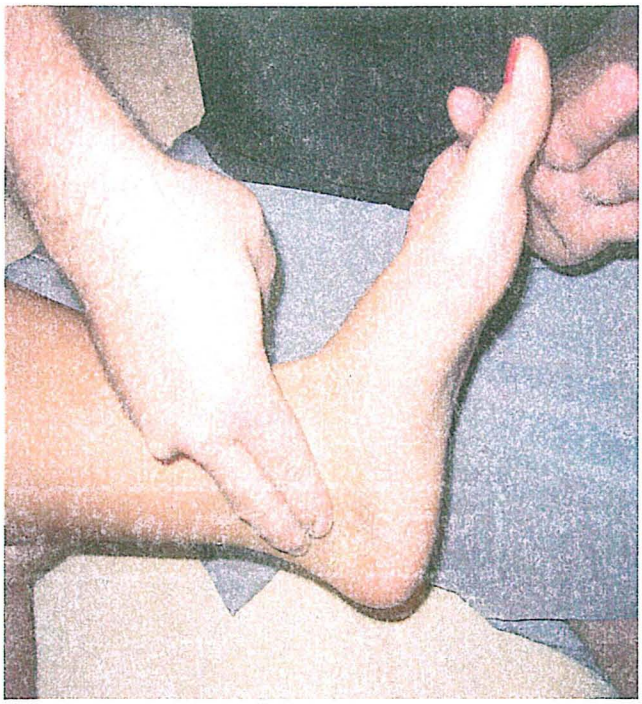


Figure 2. Posterior tibialis pulse.

Capillary Refill test[27]-Capillary refilling time is an effective way to look at both arterial and venous insufficiencies. To perform this, squeeze the great toe with your thumb and forefinger; the skin and nail where pressure is applied should blanch or lighten. When you release the pressure, the color should return immediately. If refilling takes longer than two seconds, capillary refilling is considered delayed.

Lower Extremity Sensory Assessment[25]

Many patients with diabetes have sensory loss in the lower extremity so this section will give detailed description on how to perform different sensory evaluations on your patient.

While performing the sensory assessment, the following information should be gathered:

1. Type of sensation affected
2. Quantity affected: How much body surface area is affected.
3. Degree of involvement: Examples include absent, impaired, delayed response, hypersensitivity.
4. Exact boundaries of sensory impairment.
5. Patient's subjective feelings about changes in sensation.

Prior to performing the sensory assessment, a quick assessment of the patient's ability to comprehend instructions and to communicate responses is needed because these are crucial to get an accurate sensory testing. Disoriented patients generally cannot be accurately tested.

1. Mental orientation - Ask patient questions related to time, place, and person.
2. Memory - Both long-term and short-term memory
3. Visual acuity - Eye chart
4. Peripheral field vision
5. Depth perception
6. Hearing

Patient education
Patient should be tole a full explanation of the procedure, purpose, and goals of the tests. The patient needs to understand that it will take his/her full cooperation to perform an accurate test.

Patient positioning
The patient should be in a comfortable and relaxed position (prone and supine). Patient should also be well rested with a high level of concentration. A quiet room is a must for the testing procedure.

Trial run
Prior to each test, the physical therapist should provide a trial run so the patient recognizes what is going to be performed.

Patient vision
During the test, the patient's vision should be blocked so he/she cannot see the evaluation. The use of vision can compensate for a sensory deficit and prevent accurate test results. During the trial run, the patient should be able to watch so he/she knows what to expect during the test.

Testing order
Superficial sensations should be tested first, followed by deep and combined sensation. Deep and combined sensation may not be performed on all patients. Sensory tests should be carried out in a distal to proximal direction following the main sensory nerve segmental (dermatome) supply. If a sensory defect is noted, it should be mapped out with exact boundaries. The tests should also be performed in a random, unpredictable manner with a variation in timing.

Skin conditions
Scar tissue and callus formation are generally less sensitive and will demonstrate a diminished response to testing.

Completing Sensation Diagram
Acquire sensory monofilament kit that includes filaments that exert 1 gram of force, 1 grams of force, and 75 grams of force. When using the monofilament, it should be pushed hard enough to the patient's skin so it bends. Document the lowest amount of force that the patient can sense in each area. If any other problems are noticed (dryness, swelling, redness, temperature, maceration, callus, pre-ulcer, ulcer), they should be documented on the area that is affected.

At-home foot sensation screening[28]
The Lower Extremity Amputation Prevention Program (LEAP) was developed to give diabetic patients every opportunity to get the filament and instructions for at-home screenings out to each patient in need. They are provided for free through the program. A set of instructions has been added below. To get a free LEAP Program set, contact your nearest pharmacy, call 1-800-373-4325, or browse the web at http://bphc.hrsa.gov/leap/ and fill out the form to receive a free monofilament and instructions.

Foot Deformities[23,29,30]

Foot deformities can also cause many problems with diabetic patients. While performing the foot screening, the health professional should look for foot deformities. Listed blow, with an explanation for each, are some.

Hammer/Claw Toes-A hammer toe can be seen on any toe ecept the great toe. A A claw toe has all the same characteristics as a hammer toe except it also is contracted at the DIP joint (end joint) also caused by ligament and tendon tightening.

Bunion-A bunion, also known as hallux valgus, is a painful prominent bump on the inside of the foot around the great toe. The bump is actually a bone protruding towards the inside of the foot. The big toe is caused to move towards the rest of the toes and can sometimes overlap the second toe.

Pes planus-Pes planus is a condition where the arch or instep of the foot collapses and comes in contact with the ground. This is also known as excessively flat feet.

Pes cavus-Pes cavus is a high arch that does not flatten with weight-bearing. The deformity can be located in the forefoot, midfoot, hindfoot, or a combination of these sites.

Hallux limitus-Hallux limitus is a deformity of the first MTP joint which restricts the range of motion in that joint. Normal range of motion for the MTP joint is 60 degrees. Hallux limitus can lead to no motion in the joint.

Rearfoot varus-Rearfoot varus is a biomechanical abnormality defined as the plane of the metatarsal heads inverted to the rearfoot's plane when the subtalar joint is in neutral.

PF 1st Ray-This is an oseous deformity in which the first ray lies in a plantarflexed position relative to the lesser rays when the subtalor joint in the neutral position and the midtarsal joint is locked around the oblique axis.

Forefoot varus-This is an everted position of the forefoot relative to the earfoot at the level of the midtarsal joint. Inversion of the lateral portion of the foot must occur to allow the forefoot to contact the surface during the midstance and propulsive phases of gait.

Equinus-This occurs with decreased ankle joint dorsiflexion. When this exists, compensation occurs with subtalar joint pronation which unlocks the midtarsal joint. The foot is then inhibited from normal function in propulsion.

Dorsiflexed 1st Ray-Osseous deformity in which the first ray lies in a dorsiflexed position relative to the lesser rays when the subtalor joint in the neutral position and the midtarsal joint is locked around the oblique axis. This is also known as metatarsus primus elevatus.

Foot drop-An abnormal neuromuscular disorder which affects the patient's ability to raise the foot at the ankle. Pain, weakness, and numbness may be accompanied with the loss of function.

Charcot fracture-Is a progressive deterioration of the weight-bearing joints, usually in the foot or ankle, which can lead to a fracture. This is usually characterized by an increase in edema, temperature, and erythema which may mimic gout or cellulitis.

Shoe Inspection[17,31]

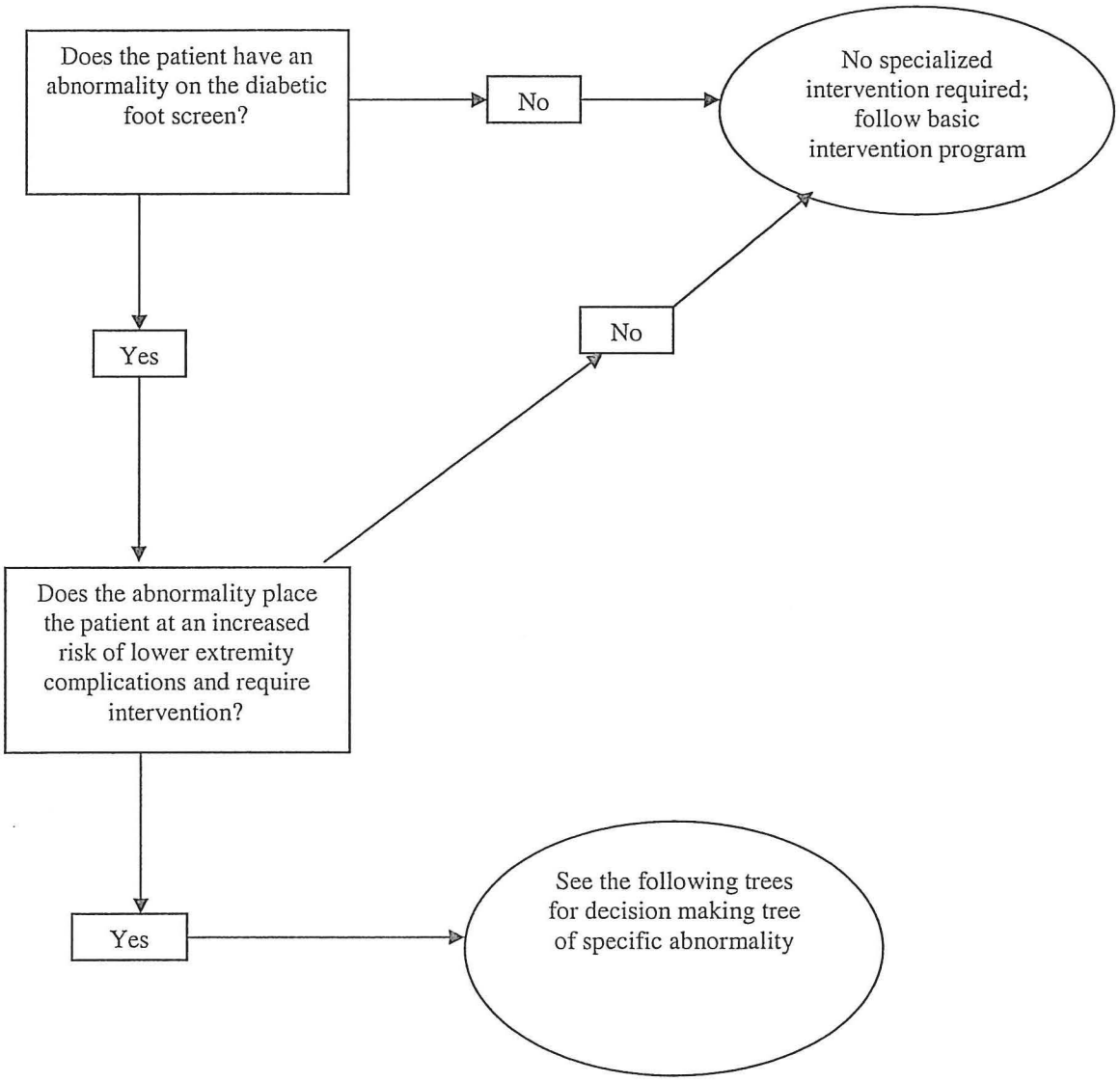
Document what type of shoes the patient has and whether the shoes or inserts are prescription. When evaluating the patient's shoes, have patient in standing. Areas that should be assessed include: space at the end of the shoe, forefoot width, heel width and height, uppers (tongue), topline (semicircle area of shoe where foot inserts around ankle), sole, and socks. There should be 1 cm of space from the end of the patient's toes to the end of the shoe. The forefoot width of the shoe shoud be slightly greater than the patient's forefoot width in standing. The heel should fit snug on the patient's foot. Uppers should be soft and breathable. Heel height should be no greater than 2.5 cm or around 1 inch in height. The sole should be cushioned and flexible only at the ball of the foot. Topline should be soft and padded. Patient should wear socks at all times when

wearing shoes. Other comments about wear pattern or any other problems with shoe should be documented in designated area.

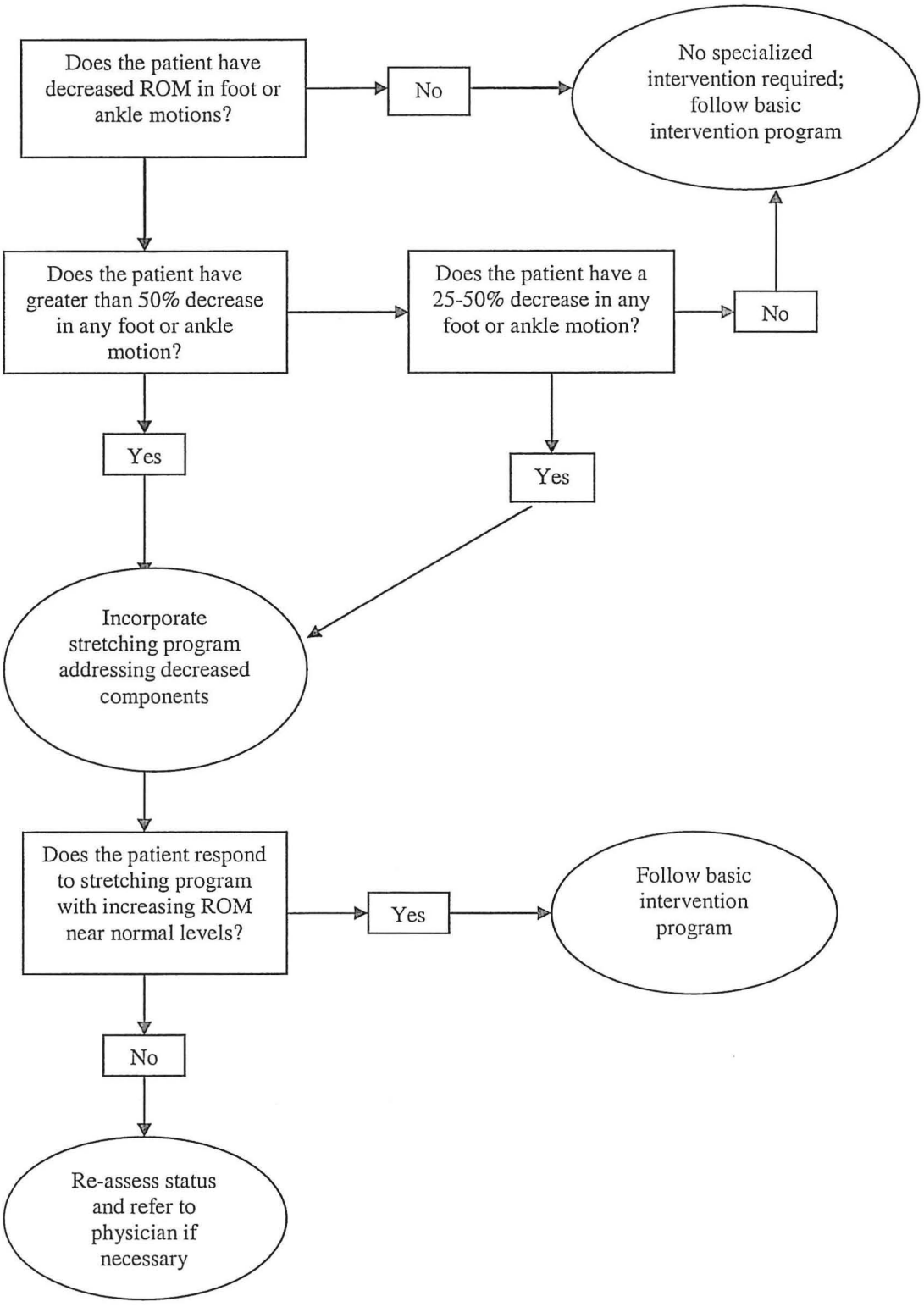
APPENDIX C

Instructions For the Use of the Clinical Decision Making Trees

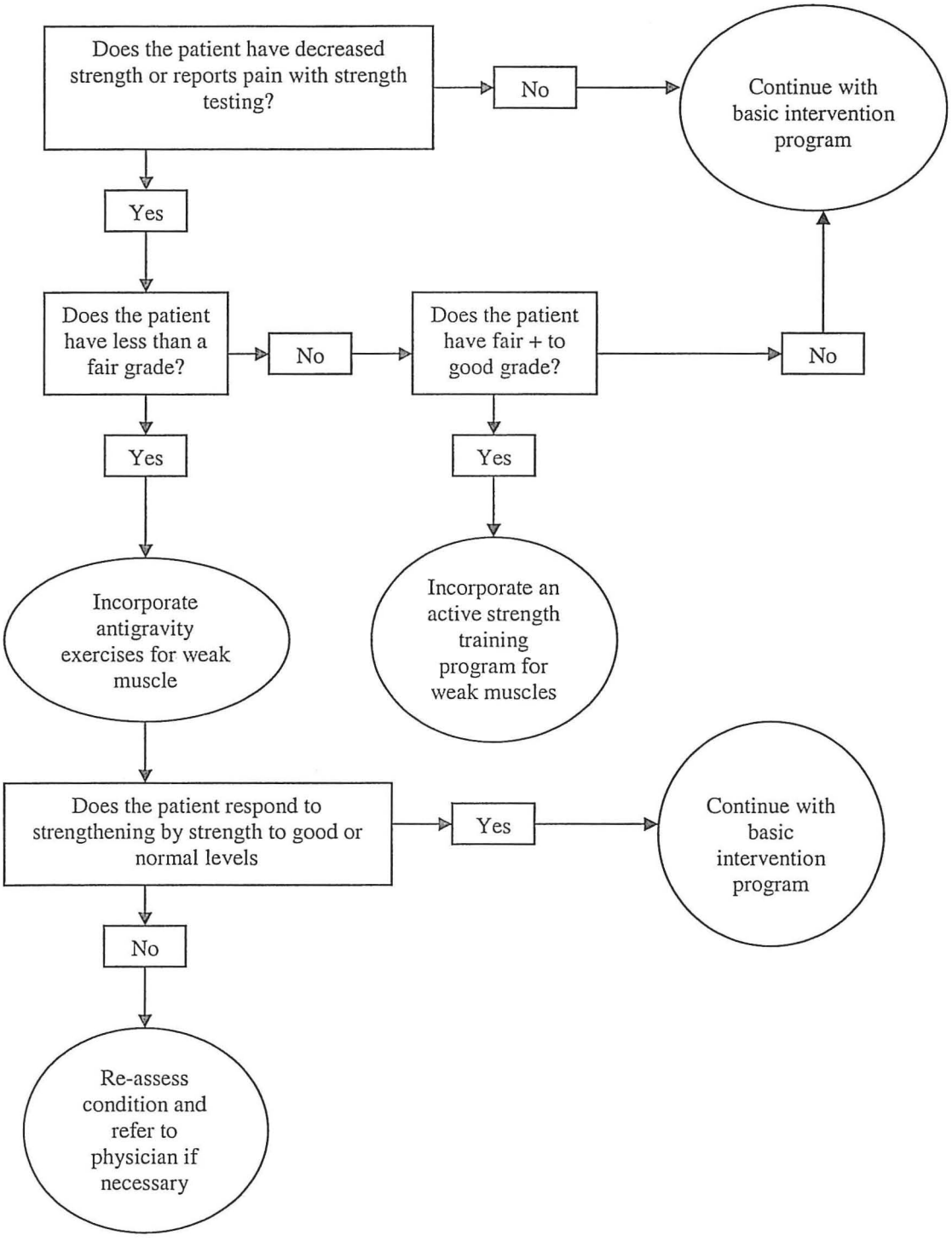
Begin in the top left corner and answer the first question. Follow the chart to the end of the tree according to appropriate answers and incorporate provided intervention.



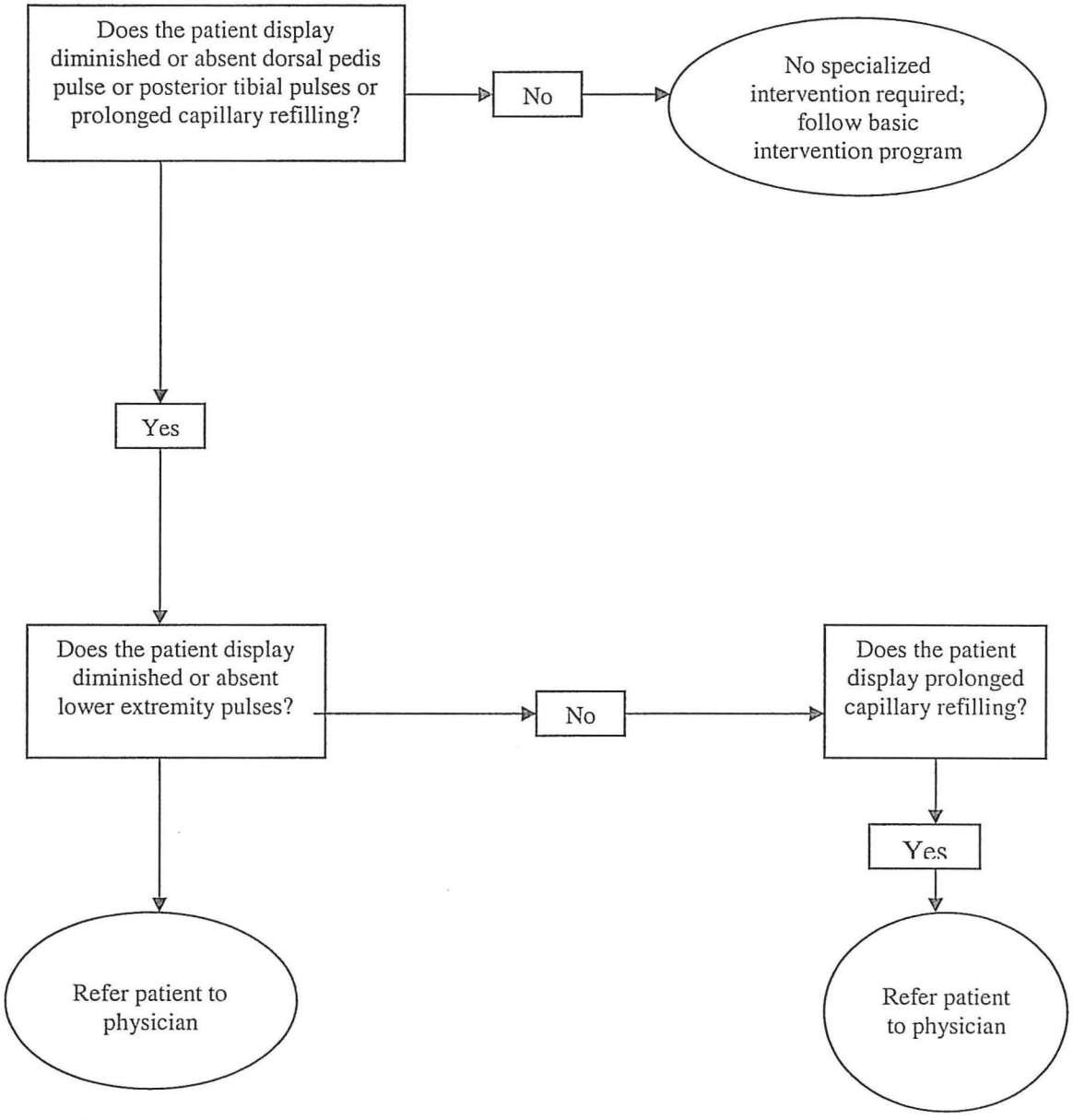
Range of Motion



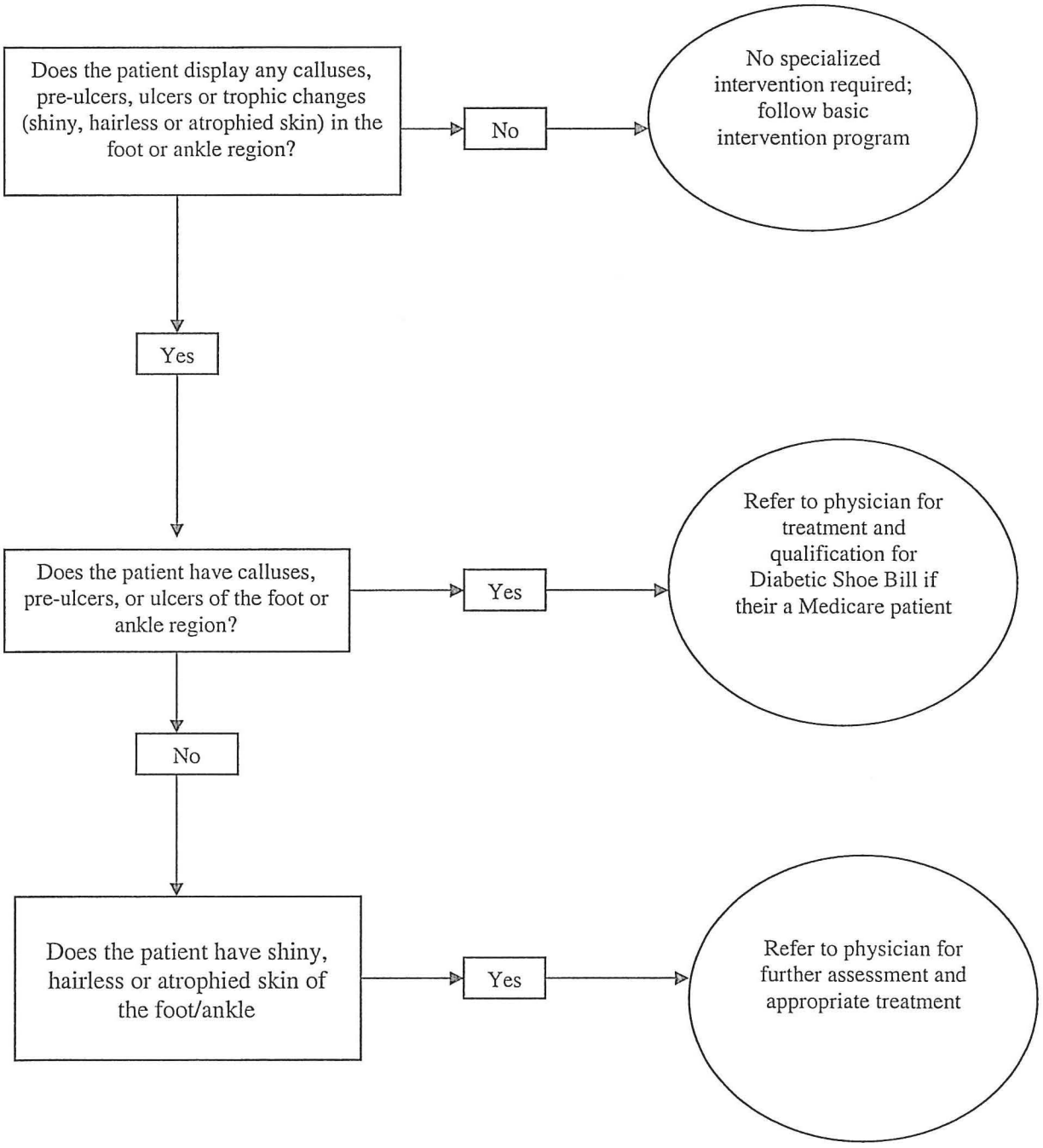
Strength


Does the patient have decreased strength or reports pain with strength testing?
No
Continue with basic intervention program
Yes
Does the patient have less than a fair grade?
No
Does the patient have fair + to good grade?
No
Yes
Yes
Incorporate antigravity exercises for weak muscle
Incorporate an active strength training program for weak muscles
Does the patient respond to strengthening by strength to good or normal levels
Yes
Continue with basic intervention program
No
Re-assess condition and refer to physician if necessary

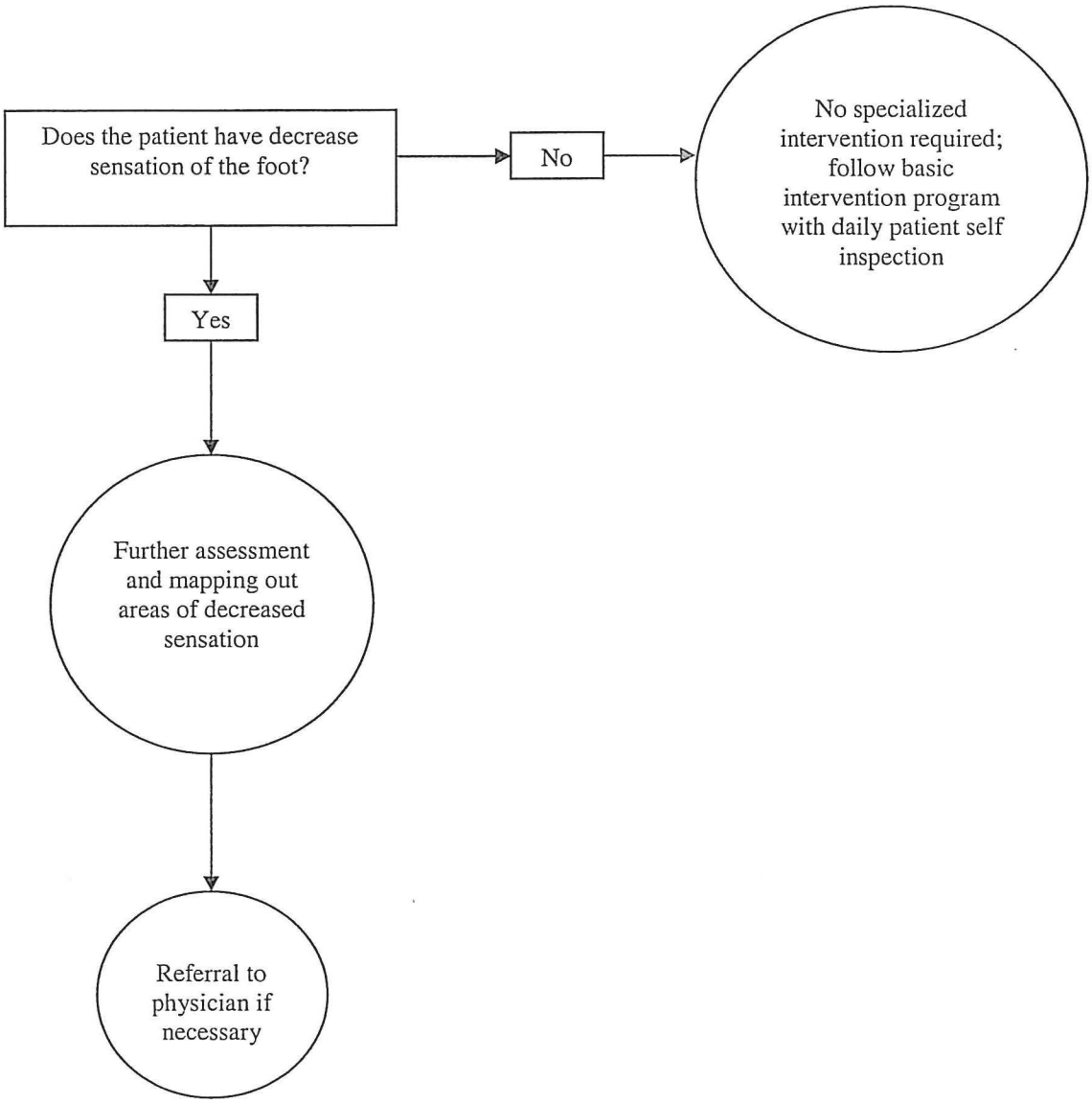
Vascular


Does the patient display diminished or absent dorsal pedis pulse or posterior tibial pulses or prolonged capillary refilling?
No
No specialized intervention required; follow basic intervention program
Yes
Does the patient display diminished or absent lower extremity pulses?
No
Does the patient display prolonged capillary refilling?
Yes
Refer patient to physician
Refer patient to physician

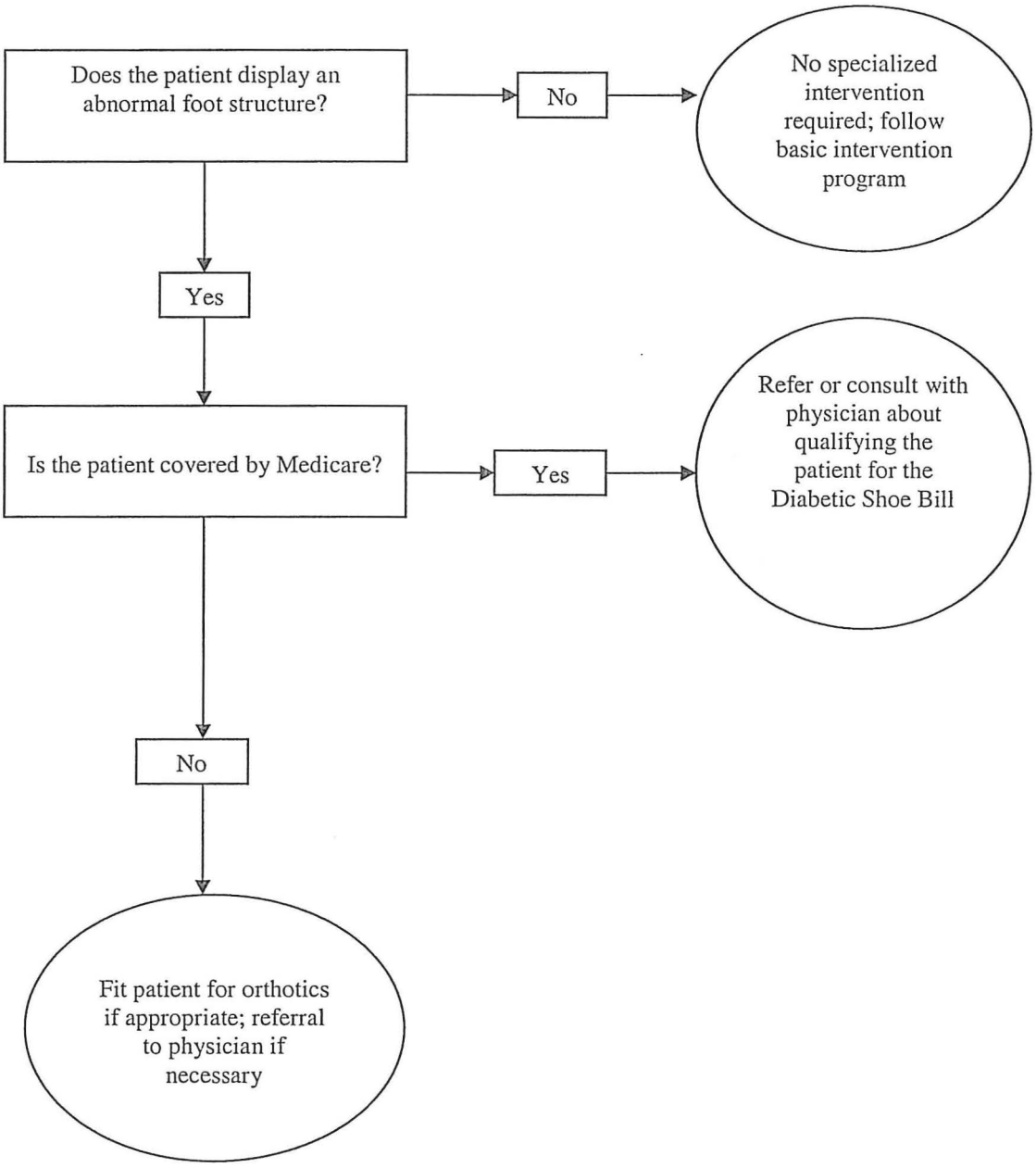
Integumentary



Sensation


Does the patient have decrease sensation of the foot?
No
No specialized intervention required; follow basic intervention program with daily patient self inspection
Yes
Further assessment and mapping out areas of decreased sensation
Referral to physician if necessary

Foot Structure



APPENDIX D

Physical Activity Readiness Questionnaire PAR-Q[32]

For most people physical activity should not pose any problem or hazard. PAR-Q has been designed to identify the small number of adults for whom physical activity might be inappropriate or those who should have medical advice concerning the type of activity most suitable for them.

Common sense is your best guide in answering these few questions. Please read them carefully and check the yes or no opposite the question if it applies to you.

YES NO

1. ☐ ☐ Has your doctor ever said you have heart trouble?
2. ☐ ☐ Do you frequently have pains in your heart and chest?
3. ☐ ☐ Do you often feel faint or have spells of severe dizziness?
4. ☐ ☐ Has a doctor ever said your blood pressure was too high?
5. ☐ ☐ Has your doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise, or might be made worse with exercise?
6. ☐ ☐ Is there a good physical reason not mentioned here why you should not follow an activity program even if you wanted to?
7. ☐ ☐ Are you over age 65 and not accustomed to vigorous exercise?

If you answered YES to one or more questions...

if you have not recently done so, consult with your personal physician by telephone or in person before increasing your physical activity and/or taking a fitness test.

If you answered NO to all questions...

If you answered PAR-Q accurately, you have reasonable assurance of your present suitability for an exercise test.

APPENDIX E

Exercise Program

Each patient will be required to complete a PAR-Q[32] assessment prior to developing a personalized exercise program. If a patient answers yes to one or more of the questions, he/she will be referred back to his/her physician. Documentation stating that the patient has completed proper testing or is cleared by his/her physician is mandatory prior to starting an exercise program. Consult with your local physical therapist or exercise physiologist prior to starting an exercise program.

Items to consider prior to starting an exercise program:

- Start slow and progress as tolerated
- Cost of exercise facilities
- Availability of facilities
- Time constraints
- Patient's likes and dislikes (hobbies)
- Should utilize an exercise partner for safety and compliance
- Receive education on exercise and diabetes
  - Types of exercise
  - Benefits
  - Special considerations

Contraindications to exercise

- Poor control of blood glucose levels
- No exercise over 250 mg/dL
- Unevaluated or poorly controlled conditions such as:
  - Retinopathy
  - Hypertension
  - Neuropathy
  - Nephropathy
- Recent photocoagulation or surgery for retinopathy
- Dehydration
- Extreme environmental temperatures (hot or cold)

Before exercising:[33]

- Monitor glucose levels
  - Do not exercise with blood glucose levels at or near 250 mg/dl
- Eat at least two hours before exercise
- Avoid insulin injections at muscular of exercise sites within one hour of exercise
- Drink approximately two 8-ounce glasses of water prior to exercise
- Do not schedule exercise during peak insulin times
- Do not exercise during periods of fasting
- Exercise in the morning is encouraged to avoid hypoglycemia

During exercise:[33]

- Include a 10-minute warm-up activity
- Carbohydrate snack every 30 minutes of exercise
- Replenish fluids frequently to avoid dehydration
- Monitor blood glucose levels every 30 minutes
- Do not exercise alone because of the possibility of hypoglycemia
  - S/S's of hypoglycemia[34]
    - Skin pale, cool, diaphoretic
    - Disoriented
    - Headache
    - Slurred speech
    - Tachycardia
    - Loss of consciousness
    - Increased heart rate
    - Weakness
    - Shaking/trembling
    - Blurred vision
    - Emotional lability
    - Coma
- Administer a fruit juice or honey to any individual with diabetes who displays signs of hypoglycemia or if unsure of hypo vs. hyper state
- Include a 5-10 minute cool-down activity

After exercising:[33]

- Monitor glucose 15 minutes after exercise
- Administer a slowly absorbed carbohydrate snack (bread, pasta, etc.)
- Reduce insulin as needed

Exercise Program

- Include all three components of exercise
  - Aerobic exercise
  - Strength training
  - Flexibility
- Intensity
  - Heart Rate Reserve (HRR)[35]
    - (220-Age) X Percent
    - Start at 55% working up to 75%
  - The Borg Rate of Perceived Exertion Scale (RPE)[36]
    - 6 No Exertion at all
      7
      Extremely Light
      8
      9 Very Light
      10
      11 Light

12
13 Somewhat Hard
14
15 Hard (Heavy)
16
17 Very Hard
18
Extremely Hard
19
20 Maximal Exertion

    - Exercise between an 11 and 16 on the RPE scale
- Aerobic Exercise
    - Frequency
        - 3-5 times per week
    - Intensity
        - HRR between 55 and 75%
        - RPE of 11 to 16
    - Type
        - Walking, jogging, biking, swimming, dancing, basketball, etc.
        - Accommodate to the patient's likes and dislikes
    - Time
        - 30-60 minutes including warm-up and cool-down
- Strength Training
    - Frequency
        - 2-3 times per week
    - Intensity
        - RPE of 12 to 16
    - Type
        - Weight lifting, strength machines, theraband, use of own body weight, etc.
        - Accommodate to the individual
    - Time
        - 2-3 sets of 8-15 repetitions
        - Work 4-6 different areas of the body
- Flexibility
    - Frequency
        - 1-2 times daily
    - Intensity
        - Mild to moderate stretch with no pain
    - Type
        - Neck bends (flexion/extension, sidebending bilaterally, rotation bilaterally), chest, shoulder circles, triceps, wrists, hamstrings, quadriceps, dorsiflexion (soleus, gastrocnemius), etc.
        - Individualize as necessary

- Time
  - 2-3 repetitions of 20 to 30 second holds

* All exercise programs will be individualized to the specific individual with diabetes. It is important to discuss the specifics of the program with the patient to increase compliance.

REFERENCES

1. Mokdal AH, Ford ES, Bowman BA, et al. Prevalence of obesity, diabetes and obesity related health risk factors, 2001. JAMA. 2003;289(1):76-79.
2. Jemal A, Ward E, Hao Y, Than M. Trends in leading causes of death in the United States, 1970-2002. JAMA. 2005;294(10):1255-1259.
3. Chang E, Stockl K, Tafesse E, Vanderplas A. Costs of lower-extremity ulcers among patients with diabetes. Diabetes Care. 2004;27:2129-2134.
4. Goldsmith JR, Lidtke RH, Shott S. The effects of range-of-motion therapy on the plantar pressures of patients with diabetes mellitus. J Am Podiatr Med Assoc. 2002;92(9):483-490.
5. National Diabetes Fact Sheet. Available at: www.cdc.gov/diabetes/faq/research.htm. Accessed May 23, 2006.
6. The Prevalence of Diabetes and Pre-diabetes. Available at: www.diabetes.org/diabetes-statistics/prevalence.jsp. Accessed May 23, 2006.
7. Ramsey SD, Newton K, Blough D, et al. Incidence, outcomes, and cost of foot ulcers in patients with diabetes. Diabetes Care. 1999;22(3):382-387.
8. Boulton AJM, Vileikyte L, Ragnarson-Tennvall G, Apelqvist J. The global burden of diabetic foot disease. Lancet. 2005;366(9498):1719-1724.

9. Colagiuri S, Marsden LL, Naidu V, Taylor L. The use of orthotic devices to correct plantar callus in people with diabetes. Diabetes Res and Clin Pract. 1995;28:29-34.
10. Mueller MJ, et al. Efficacy and mechanism of orthotic devices to unload metatarsal heads in people with diabetes and a history of plantar ulcers. J APTA. 2006;86(6):833-856.
11. Mak AFT, Tsung BY, Wong MW. Effectiveness of insoles on plantar pressure redistribution. J Rehabil Res Dev. 2004;41(6):767-774.
12. Viswanathan V, Madhavan S, Gnanasundaram S, et al. Effectiveness of different types of footwear insoles for the diabetic neuropathic foot: a follow-up study. Diabetes Care. 2004;27(2):474-477.
13. Hsi WL, Chai HM, Lai JS. Comparison of pressure and time parameters in evaluating diabetic footwear. Am J Phys Med Rehabil. 2002;81(11):822-829.
14. Pinzur MS. Shield NN, Goelitz B, et al. American Orthopaedic Foot and Ankle Society shoe survey of diabetic patients. Foot Ankle Int. 1999;20(11):703-707.
15. Janisse DJ. The therapeutic shoe bill: Medicare coverage for prescription footwear for diabetic patients. Foot Ankle Int. 2005;26(1):42-45.
16. The Diabetic Shoe Bill-Detailed Version. Available at: http://222.bigfeetstore.com/diabetic_shoe_bill_detailed.htm. Accessed May 23, 2006.

17. Mosely M. Selecting appropriate footwear for patients with diabetes. Nurs Times. 2004;100(46):48-50.

18. Koenigsberg MR, Bartlett D, Cramer JS. Facilitating treatment adherence with lifestyle changes in diabetes. Am Fam Physician. 2004;69(2).

19. Bjorgaas M, Vik JT, Saeterhaug A, et al. Relationship between pedometer-registered activity, aerobic capacity and self-reported activity and fitness in patients with type 2 diabetes. Diabetes Obes Metab. 2005;7(6):737-745.

20. Loreto DL, Fanelli C, Lucidi P, et al. Make your diabetic patients walk, long-term impact of different amounts of physical activity on type 2 diabetes. Diabetic Care. 2005;28:1295-1302.

21. Cauza E, Hanusch-Enserer U, Strasser B, et al. The relative benefits of endurance and strength training on the metabolic factors and muscle function of people with type 2 diabetes mellitus. Arch Phys Med Rehabil. 2005;86(8):1527-1533.

22. Norkin CC, White DJ. Measurement of Joint Motion: A Guide to Goniometry. 3rd ed. Philadelphia, Pa: F. A. Davis Co; 2003.

23. Gulick D. Ortho Notes: Clinical Examination Pocket Guide. Philadelphia, Pa: F. A. Davis Co; 2005.

24. Reese NB. Muscle and Sensory Testing. Philadelphia, Pa: W. B. Saunders Co; 1999.

25. O'Sullivan SB, Schmitz TJ. Physical Rehabilitation: Assessment and Treatment. 4th ed. Philadelphia, Pa: F.A. Davis Co; 2001.

26. Magee DJ. Orthopedic Physical Assessment. 4th ed. Philadelphia, Pa: W. B. Saunders Co; 2002.

27. Goodman CC, Snyder TEK. Differential Diagnosis in Physical Therapy. 3rd ed. Philadelphia, Pa: W. B. Saunders Co; 2000.

28. Lower Extremity Amputation Prevention Program. Available at: www.bphc.hrsa.gov/leap/. Accessed May 23, 2006.

29. Kisner C, Colby LA. Therapeutic Exercise: Foundations and Techniques. 4th ed. Philadelphia, Pa: F. A. Davis Co; 2002.

30. Sahrmann SA. Diagnosis and Treatment of Movement Impairment Syndromes. Philadelphia, Pa: Mosby; 2002.

31. Mercier LR. Practical Orthopedics. 5th ed. St. Louis, Mo: Mosby; 2000.

32. PAR-Q. Available at: www.d.umn.edu/Kmc/student/loon/soc/phys/parq.html. Accessed May 23, 2006.

33. Watchie J. Cardiopulmonary Physical Therapy: A Clinical Manual. Philadelphia, Pa: W. B. Saunders; 1995.

34. Goodman CC, Boissonnault WG, Fuller KS. Pathology: Implications for the Physical Therapist. 2nd ed. Philadelphia, Pa: W. B. Saunders; 2003.

35. McArdle WD, Katch FI, Katch VL. Essentials of Exercise Physiology. 2nd ed. Baltimore, Md: Lippincott Williams and Wilkins; 2000.

36. Physical Activity for Everyone: Measuring Physical Activity Intensity: Perceived Exertion (Borg Rating of Perceived Exertion Scale). Available at:

www.cdc.gov/needphp/dnpa/physical/measuring/perieved_exertion.html. Accessed May 23, 2006.